INPUT

SUPER STRUCTURE DATA

Beam Depth (FT) = beam_depth := 3.75

Number of Beams = n_beams := 3

Type of Beam Material (concrete or steel) = m_type := "concrete"

Filler Depth (ft) = filler := 0.125

Slab Depth (ft) = slab := 0.708

Rail Height (ft) = rail := 1.5 effective depth for wind

Cap Beam input

Riser Depth (bearing)(ft) = riser := 0.25

Length of Cap beam (ft) = cap_length := 25.17

Width of Cap beam (ft) = cap_width := 3.5

Depth of Cap beam (ft) = cap_depth := 6

Colum input data

Column Height (ft) = col_height := 30

Column type (round or rectangular) = col_type := "square"

Wind Load start from bottom (ft) = wind_start := 10

Number of columns (ft) = n_col := 1

Transverse column dimension (ft) = t_col := 6

Longitudinal column dimension (ft) = l_col := 3

Thermal input data

Number of lanes = $lanes := 2$

Span 1 length (ft) = $span1 := 77$

Span 2 length (ft) = $span2 := 77$

Bridge length for therman (ft) = $thermal := 154$

NOTE: Thermal is typically taken from the center of the bridge out to the outermost column. However as this distance gets longer the thermal increases, and on large bridges can be very large. Also if the column is short the thermal force can be enormous. Also the bigger you make the column the larger the thermal force gets, on the column. If the thermal starts to control, it might be prudent to remove it altogether.

Bridge skew angle (deg) = $skew1 := 90$ $skew := skew1 \cdot \frac{\pi}{180}$ $skew = 1.571$

HORIZONTAL CURVE INPUT

Design speed (mph) = $speed := 30$

Radius of Curve (ft) = $radius := 477.46$

Divisor for Centrifugal = $divisor := 1$

NOTE: Some will tell you that the centrifugal force can be divided between all the bents in the curve. If you wish to do this, input the number of bents to divide the force by here.

Use wind of live load (yes or no) = $use\_WL := \text{"yes"}$

STREAM FORCE INPUT

Drag coefficient (Cd) = $Cd := 0.7$

100 year velocity (ft/s) = $vel := 7.74$

Stream force start (ft) = $wa\_start := 10$

Stream force end (ft) = $wa\_end := 30$

CENTRIFUGAL FORCE LRFD 3.6.3

Centrifugal forces shall be taken as the product of the axle weights of the design truck or tandem and the factor C.

Design speed (mph) = $speed = 30$

Radius of Curve (ft) = $radius = 477.46$

Divisor for Centrifugal = $divisor = 1$

From LRFD 3.6.3 assume that the longitudinal force acts at a point 6 ft above the deck.

Arm for top of column (ft) = $arm\_t := 6 + slab + filler + beam\_depth + riser + cap\_depth$

$arm\_t = 16.833$

Arm for bottom of colum (ft) = $arm\_b := arm\_t + col\_height$ $arm\_b = 46.833$

Centrifugal percent = $C := \frac{4}{3} \cdot \frac{(speed \cdot 1.467)^2}{32.2 \cdot radius}$ $C = 0.168$

Centrifugal force (k) = $CF := C \cdot (8 + 32 + 32) \cdot \frac{1}{divisor}$ $CF = 12.094$

Top Moments

$M\_CF\_long\_t := CF \cdot arm\_t \cdot \sin(skew)$ $M\_CF\_long\_t = 203.584$

$M\_CF\_trans\_t := CF \cdot arm\_t \cdot \cos(skew)$ $M\_CF\_trans\_t = 1.247 \times 10^{-14}$

Bottom Moments

$M\_CF\_long\_b := CF \cdot arm\_b \cdot \sin(skew)$ $M\_CF\_long\_b = 566.413$

$M\_CF\_trans\_b := CF \cdot arm\_b \cdot \cos(skew)$ $M\_CF\_trans\_b = 3.468 \times 10^{-14}$

BRAKING FORCE LRFD 3.6.4 (BR)

Total axle weight of one truck (k) = $P := 8 + 32 + 32$ $P = 72$

Multiple presence reduction factor = (LRFD 3.6.1.1.2)

$$RF := \begin{cases} 1.2 & \text{if } lanes = 1 \\ \text{otherwise} & \begin{cases} 1.0 & \text{if } lanes = 2 \\ \text{otherwise} & \begin{cases} 0.85 & \text{if } lanes = 3 \\ 0.65 & \text{otherwise} \end{cases} \end{cases} \end{cases}$$

' = 1

Acutal Longitudinal force per column = $BR\_col := \frac{P \cdot RF \cdot 0.25 \cdot lanes}{n\_col}$ $BR\_col = 36$

Top Moments

$M\_BR\_long\_t := BR\_col \cdot arm\_t \cdot \sin(skew)$ $M\_BR\_long\_t = 605.988$

$M\_BR\_trans\_t := floor(BR\_col \cdot arm\_t \cdot \cos(skew))$ $M\_BR\_trans\_t = 0$

Bottom Moments

$M\_BR\_long\_b := M\_BR\_long\_t \cdot \frac{arm\_b}{arm\_t}$ $M\_BR\_long\_b = 1685.988$

$M\_BR\_trans\_b := M\_BR\_trans\_t \cdot \frac{arm\_b}{arm\_t}$ $M\_BR\_trans\_b = 0$

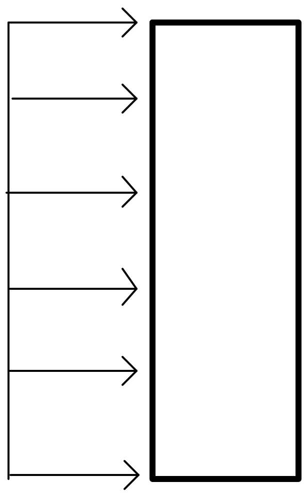
STREAM FORCE LRFD 3.7.3 (WA)

"Cd" drag coefficient = $Cd = 0.7$

100 year velocity (ft/s) = $vel = 7.74$

Stream force start (ft) = $wa\_start = 10$

Stream force end (ft) = $wa\_end = 30$



Height of stream force on column (ft) =

$height := wa\_end - wa\_start \quad height = 20$

Average force from stream (ksf) =

$Pavg := \frac{Cd}{1000} \cdot vel^2 \quad Pavg = 0.042$

Transverse force (k) =

$FT := Pavg \cdot height \cdot l\_col \quad FT = 2.516$

Moment arm for Force (ft) = $arm\_s := wa\_start + \frac{height}{2} \quad arm\_s = 20$

Bottom Moment from stream force (k*ft) = $M\_WA\_trans\_b := FT \cdot arm\_s \quad M\_WA\_trans\_b = 50.322$

DESIGN VELOCITY OF WIND LRFD 3.8.1.1

If the height of exposed area to the wind force is < 30 ft use the base velocity of 100 mph. If the height is > 30 ft then use

$$VDZ = 2.5 \cdot Vo \cdot \left(\frac{V30}{VB}\right) \cdot \ln\left(\frac{Z}{Zo}\right)$$

Exposed height (ft) = $Z := col\_height - wind\_start$ $Z = 20$

$V30 := 100$ $Zo := 0.23$

$VB := 100$ $Vo := 8.2$

$$VDZ := \begin{cases} 100 & \text{if } Z \le 30 \\ 2.5 \cdot Vo \cdot \left(\frac{V30}{VB}\right) \cdot \ln\left(\frac{Z}{Zo}\right) & \text{otherwise} \end{cases}$$

$VDZ = 100$

LRFD 3.8.1.2.1 WIND PRESSURE ON THE STRUCTURE

In the absence of more precise data, design wind pressue, in ksf, may be determined as

$$PD = PB \cdot \left(\frac{VDZ}{VB}\right)^2$$

Base wind pressure (table 3.8.1.2.1-1) (ksf) = $PB := 0.05$

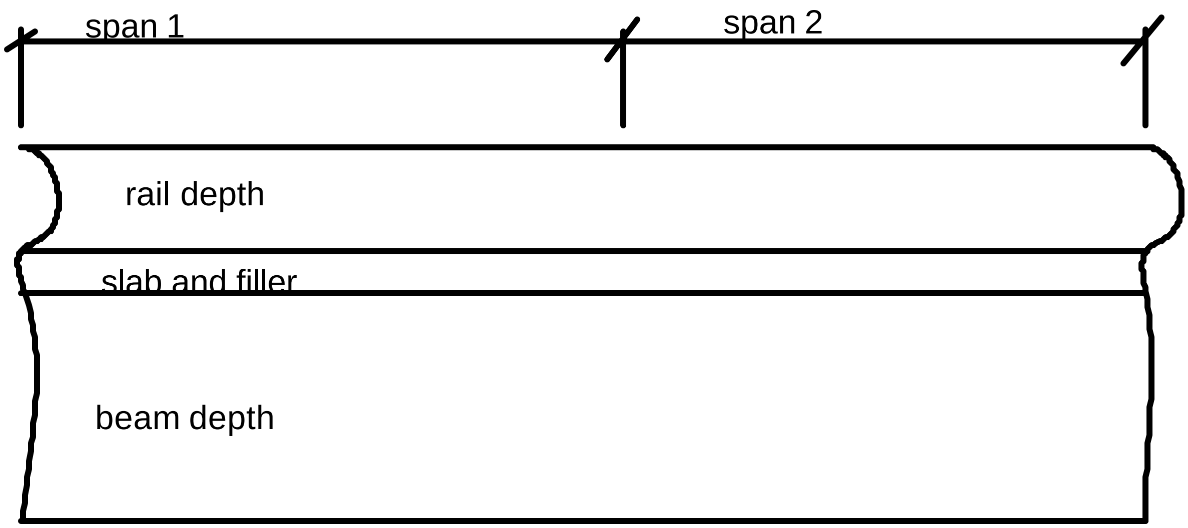
Design wind pressure (ksf) = $PD := PB \cdot \left(\frac{VDZ}{VB}\right)^2$ $PD = 0.05$

If the total wind loading shall not be taken less than 0.30 k/ft on beam or girder spans.

WIND ON STRUCTURES LRFD 3.8.1.2 (WS)

Wind on structure is divided into two parts. wind on super, and wind on sub structure. These are calculated separately and combined inder "WS".

Wind on Super-structure (divide between columns)



Check total loading per foot.

Height (ft) = $a1 := rail + slab + filler + beam\_depth$ $a1 = 6.083$

Load per foot (k/ft) = $a2 := a1 \cdot PD$ $a2 = 0.304$

Load per foot to use = $a3 := \begin{cases} 0.3 & \text{if } a2 \le 0.3 \\ a2 & \text{otherwise} \end{cases}$ $a3 = 0.304$

Centroid (ft) = $cent := \frac{(rail + slab + filler + beam\_depth)}{2}$ $cent = 3.042$

Moment arm for top of column (ft) = $arm\_t1 := cent + riser + cap\_depth$ $arm\_t1 = 9.291$

Moment arm for bottom of column (ft) = $arm\_b1 := arm\_t1 + col\_height$ $arm\_b1 = 39.291$

Top Moments

$$M\_W1\_long\_t := a3 \cdot \left(\frac{span1 + span2}{2}\right) \cdot \cos(skew) \cdot \frac{arm\_t1}{n\_col}$$ $M\_W1\_long\_t = 1.332 \times 10^{-14}$

$$M\_W1\_trans\_t := a3 \cdot \left(\frac{span1 + span2}{2}\right) \cdot \sin(skew) \cdot \frac{arm\_t1}{n\_col}$$ $M\_W1\_trans\_t = 217.603$

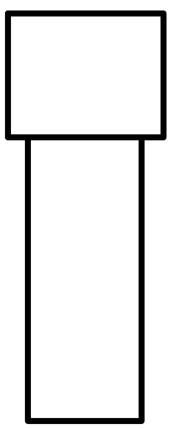
Bottom Moments

$$M\_W1\_long\_b := M\_W1\_long\_t \cdot \frac{arm\_b1}{arm\_t1}$$ $M\_W1\_long\_b = 5.634 \times 10^{-14}$

$$M\_W1\_trans\_b := M\_W1\_trans\_t \cdot \frac{arm\_b1}{arm\_t1}$$ $M\_W1\_trans\_b = 920.189$

Wind on Sub-structure

For Transverse direction do not divide between columns



Use the following for the transverse wind force

$PD = 0.05$

Loaded area (ft^2) =

$$LA2 := cap\_width \cdot cap\_depth + l\_col \cdot col\_height$$

$LA2 = 111$

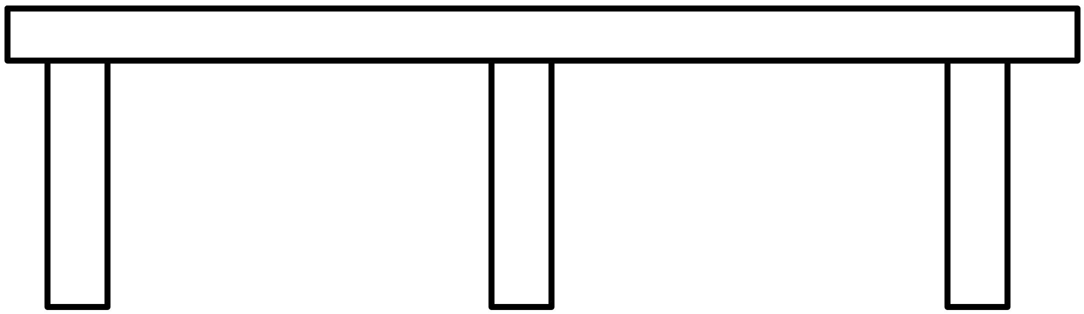
Moment arm for bottom

$$arm\_b2 := \frac{cap\_width \cdot cap\_depth \cdot \left(col\_height + \frac{cap\_depth}{2}\right) + col\_height^2 \cdot l\_col \cdot 0.5}{LA2}$$ $arm\_b2 = 18.405$

Applied Transverse force (k) = $PT2 := LA2 \cdot PD$ $PT2 = 5.55$

Bottom Transverse moment = $M\_W2\_trans\_b := PT2 \cdot arm\_b2$ $M\_W2\_trans\_b = 102.15$

For the longitudinal direction divide between columns



Use the following = $PD = 0.05$

Loaded area (ft^2) = $LA3 := cap\_length \cdot cap\_depth + col\_height \cdot t\_col \cdot n\_col$

$LA3 = 331.02$

Longitudinal Force (k) = $PL3 := LA3 \cdot PD$ $\quad PL3 = 16.551$

Moment arm (ft) = $$arm\_b3 := \frac{cap\_length \cdot cap\_depth \cdot \left(col\_height + \frac{cap\_depth}{2} \right) + n\_col \cdot col\_height^2 \cdot t\_col \cdot 0.5}{LA3}$$

$arm\_b3 = 23.212$

Bottom Longitudinal moment = $M\_W2\_long\_b := \frac{PL3 \cdot arm\_b3}{n\_col}$ $\quad M\_W2\_long\_b = 384.183$

Wind Load totals "W"

Top Moments

$M\_W\_long\_t := M\_W1\_long\_t$ $\quad M\_W\_long\_t = 1.332 \times 10^{-14}$

$M\_W\_trans\_t := M\_W1\_trans\_t$ $\quad M\_W\_trans\_t = 217.603$

Bottom Moments

$M\_W\_long\_b := M\_W1\_long\_b + M\_W2\_long\_b$ $\quad M\_W\_long\_b = 384.183$

$M\_W\_trans\_b := M\_W1\_trans\_b + M\_W2\_trans\_b$ $\quad M\_W\_trans\_b = 1022.339$

Wind of Live Load LRFD 3.8.1.3 (WL) divide between columns

From LRFD 3.8.1.3 I shall apply the following = $WT4 := 0.1$ Normal component

$WL4 := 0.038$ Parallel component

Note: Actual bridge is not skewed, these numbers are for demonstration purposes.

Moment arm top (same as for longitudinal force from LL) = $arm\_t = 16.833$

Moment arm bottom (same as for longitudinal force from LL) = $arm\_b = 46.833$

Transverse force (k) = $PT4 := \frac{span1 + span2}{2} \cdot WT4$ $PT4 = 7.7$

Longitudinal force (k) = $PL4 := \frac{span1 + span2}{2} \cdot WL4$ $PL4 = 2.926$

Top Moments

$M\_WL\_long\_t := (PL4 \cdot \sin(skew) + PT4 \cdot \cos(skew)) \cdot \frac{arm\_t}{n\_col}$ $M\_WL\_long\_t = 49.253$

$M\_WL\_trans\_t := (PL4 \cdot \cos(skew) + PT4 \cdot \sin(skew)) \cdot \frac{arm\_t}{n\_col}$ $M\_WL\_trans\_t = 129.614$

Bottom Moments

$M\_WL\_long\_b := M\_WL\_long\_t \cdot \frac{arm\_b}{arm\_t}$ $M\_WL\_long\_b = 137.033$

$M\_WL\_trans\_b := M\_WL\_trans\_t \cdot \frac{arm\_b}{arm\_t}$ $M\_WL\_trans\_b = 360.614$

SUMMARY

top =

	0	1	2	3
0	"load type"	"P"	"MT"	"ML"
1	"CF"	0	$1.247 \cdot 10^{-14}$	203.584
2	"B"	0	0	0
3	"WA"	0	0	0
4	"W"	0	217.603	$1.332 \cdot 10^{-14}$
5	"WL"	0	129.614	49.253
6	"BR"	0	0	605.988
7	"T"	0	0	0
8	"ICE"	0	0	0
9	"EQ"	0	0	0

bottom =

	0	1	2	3
0	"load type"	"P"	"MT"	"ML"
1	"CF"	0	$3.468 \cdot 10^{-14}$	566.413
2	"B"	0	0	0
3	"WA"	0	50.322	0
4	"W"	0	1022.339	384.183
5	"WL"	0	360.614	137.033
6	"BR"	0	0	1685.988
7	"T"	0	0	0
8	"ICE"	0	0	0
9	"EQ"	0	0	0